

## **The Safe and Proper Use of Wrenches: An Instructional Video**

David E. Croft  
Department of Educational Technology  
University of Hawai'i at Mānoa  
Honolulu, Hawai'i, U.S.A.  
croft@Hawai'i.edu

**Abstract:** This instructional design project examined whether an instructional design module, in the form of a video lesson in DVD format, could be an effective method of delivering consistent, anytime, anywhere instruction for a secondary automotive technology course. Design elements that were investigated included those derived from cognitive theories of multimedia learning, such as signaling, spatial contiguity, temporal contiguity, personalization, and modality, as well as presentation length, the use of still images, animated images, color, and font. College of Education students at the University of Hawai'i at Mānoa were pre-tested and post-tested to determine material retention, and post-surveyed to determine the functionality of design elements. The findings revealed that 91% of the participants were able to correctly answer 90% of the post-test questions. The survey results indicated that the design elements were successfully implemented.

### **Introduction**

According to Mayer (2003), multimedia's instructional potential lies in the skillful blending of words and images, which results in deeper learning than the more traditional method featuring words alone. A recorded multimedia instructional module is potentially an effective method of delivering consistent, anytime, anywhere instruction.

Consistency in instruction in a hands-on class, such as Automotive Technology, is paramount to effective learning, particularly when teaching safety and core fundamentals, for example, the safe and proper use of a subset of hand-tools, wrenches. The scheduling of first year Automotive Technology classes at one Oahu secondary school creates a challenging situation. Instructional periods are scheduled in blocks of eighty minutes. There are two periods, classes, of first year Automotive Technology students, an A5 and a B6. Each class meets every other school day. "A" days consist of periods one, three, five and seven. "B" days consist of periods two, four and six. One class is scheduled in period five; the other class in period six. Both classes in the first quarter of the year focus on general shop safety, as well as the safe and proper use of basic hand-tools. Each class in the second quarter, and half of the third quarter, has a different focus. The period five class is focused on internal combustion engines. The period six class is focused on brake systems. After the middle of the third quarter, period five changes to brake systems, while period six shifts to internal combustion engines. All students proceeding to the

advanced class must enter with similar basic knowledge. Consequently, a clear need exists for an effective method of conveying consistent information in this essentially hands-on class, where students will ultimately be asked to physically apply their knowledge during a demonstration, with a question and answer session, while in the shop.

Since learning theory indicates that students have a variety of learning styles, the information should be presented in various formats, for example, audio, visual and kinesthetic. Therefore, a five minute video-based instructional module, in DVD format, was designed to teach the safe use of a subset of basic automotive tools, wrenches, to secondary school students in Honolulu, Hawai'i. College of Education students at the University of Hawai'i at Mānoa were selected as subjects to evaluate the module because they have sufficient background in design, and possess a mechanical background and knowledge base, ranging from novice to some prior knowledge, which is similar to that of the researcher's actual students. Participants were pre-tested and post-tested to determine material retention, and post-surveyed to determine the functionality of design elements.

### **Synopsis of Salient Literature**

Multimedia provides fertile ground for designing instructional modules to satisfy the inquiring minds of digital natives. However, to be successful, multimedia must be designed in ways which are consistent with how people learn (Mayer, 2003). How does the learner process multimedia information? Does animation impact learning, and if so, in what way? Is multimedia inherently able to facilitate learning or is design critical? Can multimedia motivate and engage, and if so, under what conditions? Can the "promise of multimedia learning" be realized by an instructional video in an Automotive Technology class for high school students? This literature review will provide insight into these questions.

**Multimedia learning theory and its implication for design.** By the late 1970's, the behaviorist model of learning, which emphasizes stimulus-response, started to be replaced by the cognitive model, which focuses upon mental events (Saettler, 1990). The information processing theory, which incorporates the metaphor of the computer, centers upon the manner in which information is stored in memory. Januszewski and Molinda (2008) citing Atkinson and Shiffrin's research, state that information transitions from sensory memory, to short term memory, to long term memory.

It is from the cognitive perspective that Mayer formulated a theory of multimedia learning and suggested its implications for multimedia design. Mayer, (Lowe & Shnotz, 2008) formulated his multimedia learning theory based upon three major ideas from cognitive learning theories: dual channels, limited capacity, and generative processing.

**Dual channel assumption.** The dual channel assumption is based upon the fact that sensory information is introduced to the nervous system from external stimuli, essentially auditory and visual stimuli. Two separate channels, auditory and visual, gather and

process data through the eyes or ears (Mayer, 2002, 2003). This assumption is based upon the research of Pavio and Baddley (Lowe & Shnotz, 2008).

***Limited cognitive capacity assumption.*** Mayer assumed that there is a limit to the amount of visual and auditory data that can be processed at any given time before either or both channels become overloaded (Mayer, Heiser & Lonn, 2001). This has been supported by other research (Paas, Renkl & Sweller 2003).

***Processing assumption.*** There are three types of cognitive processing: extraneous processing, which pertains to processing that is not directly connected to the instructional goal; essential processing, which consists of basic processing that that is pertinent to the learning objective, for example, choosing words and images and beginning to organize them; and generative processing, which refers to integrating the relevant material (Lowe & Shnotz, 2008).

Extraneous processing needs to be reduced in order to preserve enough cognitive capacity for the learner to integrate and process the essentials of the lesson (Paas et al, 2003). According to Mayer (Lowe & Shnotz 2008), there are five ways to reduce extraneous overload in multimedia lessons: coherence, signaling, redundancy, spatial contiguity and temporal contiguity. The coherence principle indicates that individuals learn more effectively when extraneous information is avoided, due to the limitations of cognitive load (Mayer & Jackson, 2005; Moreno & Mayer, 2000). The signaling principle refers to another means of reducing extraneous load by giving cues to the learner regarding the importance and organization of the information being presented (Mautone & Mayer, 2001). Redundancy refers to the need to create a video lesson in which the narration is presented simultaneously with the animation. The spatial contiguity principle indicates that printed words should be positioned next to the related part of the animation; this reduces visual scanning and avoids extraneous overload (Moreno & Mayer, 1999). Temporal contiguity means that individuals learn more effectively when animation and narration are simultaneous, instead of following one another (Mayer & Anderson, 1992).

***Essential processing.*** During this phase, which is the initial processing pertinent to the multimedia lesson, processing overload may occur and must be reduced (Lowe & Shnotz, 2008). This may be accomplished by applying three principles: the segmenting principle, the pre-training principle, and the modality principle (Lowe & Shnotz, 2008). The segmenting principle refers to presenting an animation in segments, which can be viewed by the learner at his or her own pace. The pre-training principle indicates that individuals learn more successfully when they have been previously introduced to the names and major characteristics of the main components (Mayer, Mathias & Wetzel, 2002). The modality principle suggests that individuals learn best when animation and narration are presented together, as opposed to presenting animation with on-screen text (Moreno & Mayer, 1999, 2002). This is beneficial because the auditory channel processes verbal expression, while the visual channel processes the animation, thus reducing the visual load. When on-screen text is presented, the visual load is increased unnecessarily.

***Generative processing.*** This refers to choosing pertinent parts of the animation and

narration, organizing them into mental models and integrating them with each other, as well as with previously acquired knowledge (Lowe & Shnotz, 2008). Lowe and Shnotz cite Reeves and Nass 1996 research in pointing out that generative processing is more likely to occur when there is a perception of a social partnership between the learner and the computer based instructional lesson. To establish such a social partnership, Lowe and Shnotz advocate using an informal conversational style to personalize the video lesson. Mayer, Fennel, Farmer and Campbell (2004) added that, “. . . if personalized versions encourage additional constructive processing – such as organizing and integrating the material – then personalized versions should create their greatest effects on measures of transfer” (p. 393). Lowe and Shnotz (2008) also advocate using a human voice rather than an electronic voice.

Prior knowledge may also affect learner outcome while watching animation. It has been found that novice students benefit from still graphics with regard to learning descriptive as well as procedural knowledge, because learners with low domain-general knowledge may not be able to distinguish the most relevant features of the image or animation from those that are visually obvious but not key to the concepts being presented (ChanLin, 2001). Experienced students benefit from animation because they are better able to identify the salient visual information (ChanLin, 2001). Lowe (2003) conducted research using meteorology lessons which supports this finding.

## **Methodology**

**Project purpose.** The purpose of this project was to develop a five minute video-based instructional module, in DVD format, and have University of Hawai'i at Mānoa, College of Education students evaluate the module's structure, interface, functionality, and delivery of content. The module was designed to teach the safe and proper use of a subset of basic automotive tools, wrenches, to secondary students in Honolulu, Hawai'i.

College of Education students were chosen to evaluate this phase of the module's development because they should have sufficient background in design, and would possess a mechanical background and knowledge base, ranging from total novice to some prior knowledge, which is similar to that of the researcher's actual students.

**Objectives.** Educational objectives provide guidelines to one's curriculum and the curriculum in turn guides the instruction. The objectives also aid in determining the methods and specifications of evaluation. In this case, the target audience is the first year Automotive Technology student within the secondary level of education, and one major objective is to increase the student's knowledge base of the hand-tools used within the automotive industry, as well as their safe and proper use.

This project had two goals: first, to determine if the participants could accurately answer nine out of ten multiple-choice questions regarding the safe and proper use of wrenches, after viewing a five minute video-based instructional module on the topic. The second goal was to analyze the design elements of the module in terms of whether they assisted or hindered retention of the information presented. The first goal, the educational

objective, falls within Bloom's cognitive domain, under "knowledge." Bloom's taxonomy has been selected because the Hawai'i Department of Education has moved from Gagne to Bloom. Bloom's taxonomy has three domains: cognitive, affective and psychomotor; each has varying levels of achievement (Krathwohl, Bloom & Masia, 1965).

**Cognitive.** This domain involves objectives as simple as recalling previously learned material up to the act of creatively combining a variety of ideas or materials to synthesize something original. The target audience has varying levels of prior knowledge, from the novice to those with some experience with hand-tools. Although recalling previously learned material is a lower level objective, it is fundamentally critical to performing safely in this environment. With practice, a student should be able to assess a given situation and select an appropriate wrench to use.

**Affective.** The objectives of the affective domain range from simply giving attention to specific phenomena, up to the consistent demonstration of internalized qualities, such as character and conscience. In this situation, the student should demonstrate confidence when discussing and using wrenches, as well as consistently practice safe and proper use.

**Design.** The following equipment was used in the production of the video: a Sony DV Cam model number DCR-HC 48, Sony DV tape DVM 60, Canon tripod deluxe 200, Apple iMac and MacBook Pro, LaCie external hard drive designed by FA Porsche and a Shure SM58 microphone, with a Shure X2U computer interface. Apple, Inc. was the primary source of software used to create the video: Final Cut Pro was used to "log and capture," as well as to edit the video; SoundTrack was selected to record the narration; and DVD Studio Pro was chosen to compile and burn the DVDs. Additionally, OpenOffice and Preview were used to create the "Slide" elements and captions of the video. Music originated from a royalty free library for educational applications.

The audio and video aspects of the module were reinforced by a fill-in-the-blank worksheet. Increased learner control affects information retention, therefore the video was divided into chapters allowing the student to not only fast-forward, rewind and pause, but also to select specific sections of the video as needed. This allowed the student to make use of the worksheet at his or her own pace. Although the viewing, listening and writing activities were condensed, collectively the three have an impact on retention.

Since students would use the module independently, it was critical to design an instructional module that would motivate the student. A review of relevant literature indicated that instructional modules with video have higher appeal than those with only audio and text (Pomales-García & Liu, 2006). Print materials were enhanced by adding audio-video in a study by Gold, Swann and Chief (2002). In addition, module length impacts learner motivation (Pomales-García & Liu, 2006).

**Site.** The evaluation was conducted on campus in a classroom at the University of Hawai'i at Mānoa, College of Education, Wist Hall, Room 234.

**Test audience.** University of Hawai'i at Mānoa, College of Education students were

recruited through two E-mails to evaluate the module. The first E-mail drew only three respondents, therefore the recruiting process was modified. A second E-mail was sent, which stated that each participant would be compensated for his or her time, in the form of a \$10.00 gift card. This resulted in an additional eight respondents and brought the total to 11. Participants ranged in age from early-twenties to mid-fifties, both sexes, and came from diverse ethnic backgrounds.

### **Instrumentation**

Twenty externally unmarked packets were created. Within each packet was a numbered set of materials, which included a pre-test, a DVD, a worksheet, a post-test and a post-survey. The pre-test and post-test each consisted of ten multiple choice and true-false questions to evaluate baseline subject knowledge and retention. The survey contained ten Likert Scale questions, and two open-ended questions to address design issues. The packets were shuffled, and each participant received a random packet upon arriving at the test site.

Participants were directed to open the packet, take the pre-test, load the DVD, and view the instructional module while utilizing the worksheet. Upon completion of the video module, participants took the post-test, completed the survey, returned their packet to the researcher and received their gift card as they exited.

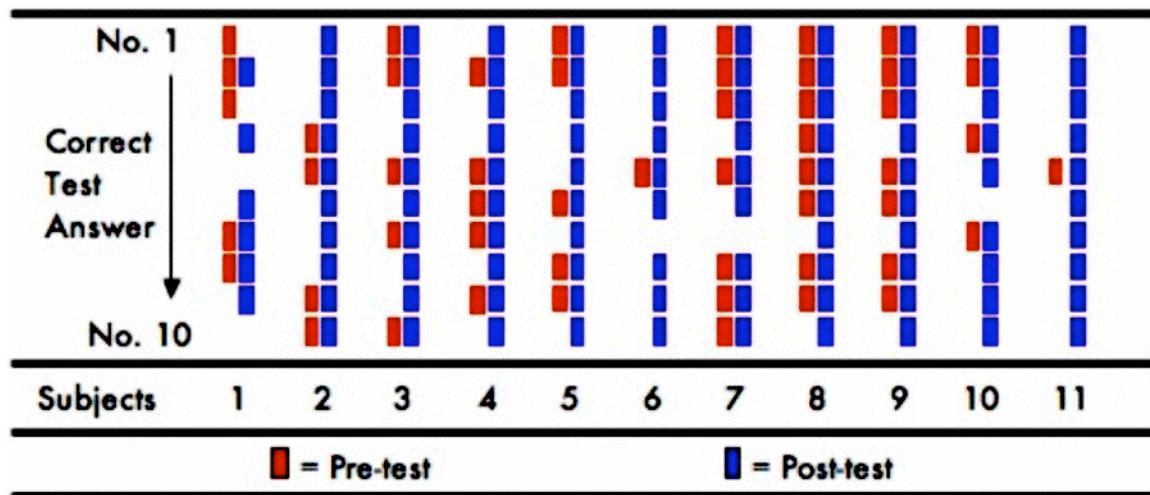
### **Findings**

The results of the ten-question pre-test showed that, as a group, the average number of questions answered correctly was 4.73, and the median was 5. Approximately one third of the participants had a minimal mechanical background, with an average pre-test score of 2.5. Approximately one third of the participants seemed to have had an average mechanical background; the score for each of the four members of this group was 5. The final group appeared to have had more than an average mechanical background, as indicated by their average score of 7.33. Therefore this group appears to be similar in their mechanical background and knowledge base to that of the researcher's actual students.

Among the apparent novices, with regard to the two key questions most commonly answered incorrectly on the pre-test, eight of the eleven participants did not know that both ends of a combination wrench would fit the same size nut or bolt. Six of those eight participants did not know that each end of a box or open end wrench would not fit the same size nut or bolt. After viewing the video, six of the original eight were able to provide correct responses to those key questions.

The ten-question post-test results of the group were positive; the average number of questions answered correctly was 9.36, and the median was 10. One participant had six correct answers; three gave nine correct responses, and seven achieved a perfect score of ten. If these had been actual students, it appears that the student with the score of six would need more personalized instruction or additional review. The findings revealed

that 91% of the participants were able to correctly answer 90% of the post-test questions. Thus, the data indicated that the video-based instructional module was effective in delivering instruction.



**Figure 1. Correctly answered questions, 1 through 10, of the eleven subjects' corresponding pre and post-tests.**

An anomaly observed was that three participants gave a correct answer in their pre-test, yet they provided an incorrect answer to the corresponding question in the post-test. If they knew the correct answer in the pre-test, prior to viewing the video, why didn't they respond correctly, to the corresponding question, after viewing the video? Note, the questions involved in this anomaly were different for each of the three participants, and there was no similar concept or unifying theme in these questions. Subject number 1 answered question number 8 correctly in the pre-test, but answered incorrectly the corresponding number 3 post-test question. Subject numbers 7 and 10 answered correctly the pre-test questions numbered 2 and 1 respectively, but answered incorrectly the corresponding post-test questions, numbered 7 and 6 respectively (see Figure 1).

If they had all gotten the same specific pre-test question correct with its corresponding post-test question incorrect, the wording of the post-test question would need to be examined. However, the questions involved were different for each of these three participants, and there was no related theme to the questions, which made it difficult to suggest a reason for the anomaly.

The video-based module was created using a number of specific design elements, but the Likert Scale survey only investigated subjects' attitudes regarding the following design elements: control, contrast, still images, narration, and video. According to the participants' responses, control of the module had a positive effect; it received an average score of 7.63. The contrast between text and its background had a positive effect; the average score pertaining to contrast was 8. Still images had a positive effect, as evidenced by an average score of 8.23. The narration supported the visuals; the average score was 8.46. Finally, the video demonstration of wrench usage on the video resulted in a positive effect, as supported by an average score of 8.5.

Each of the various design elements contributed to the overall effectiveness of the video module. Control was provided to the participants by an on-screen DVD control unit, which enabled them to perform all standard operations, such as start, pause, fast forward, rewind and stop. Also featured were chapter options, which allowed the viewer to advance immediately to a specific chapter, as well as to revisit a chapter, according to his or her individual needs. Contrast was achieved by using yellow text on a dark green background. Still images were specifically incorporated for novice learners. The narration was designed specifically to support the visuals, and utilized “cueing” or “signaling.” Thus, the narration started ten frames prior to its related visual element, in order to support instruction by “cueing” or “signaling” the viewer as to the importance of the information. The narration also incorporated a personalized approach, that is a less formal style of speech was used, such as “you” instead of “the student.” The video demonstration was to support participants who had some degree of prior experience and/or knowledge. It was important to include both stills and video because students ranged from novices to those with some experience; stills tend to be more effective with novices, and video tends to benefit those with some prior experience and/or knowledge.

According to the Likert Scale results, all five of the design elements addressed had a positive effect. There were only three Likert Scale questions that resulted in an average score below 8. The two questions regarding the effect of control yielded average scores of 7.55 and 7.73. The question regarding the effect of contrast resulted in an average score of 7.91. There were certain discrepancies. For example, one participant was neutral regarding the effect of contrast, and one individual indicated a negative effect regarding the controls, assigning a 3.5 to the Likert Scale questions pertaining to control.

Two open ended questions were posed to participants to determine what they liked most and what they liked the least about the video. The majority of the responses clustered around the same five elements: control, contrast, still images, narration, and video that were addressed in the Likert Scale questions. One participant stated that the video controls were “primitive.” This comment was puzzling because the controls featured in the DVD included all the options that are commonly available in any DVD program. In contrast, one participant stated, “I loved that I had control over the video.”

There were some responses that were not related to the five major design elements. For example, two participants described the background music as being “distracting” or “unnecessary,” except for its use at the video's beginning and end. One participant found that it “complimented [the] monotone narration.” Two others found segments of the video to be “slow” or commented that it “makes you wait.” This is an enigma because the controls enabled the viewer to fast forward the video. Another found “the speed of the video was perfect.” One participant commented that there was “poor video quality,” but another wrote that it “looked and sounded professional.” While returning the packet, one participant commented, “I didn't realize that there was so much to know about wrenches.”

## **Discussion**

The purpose of the study was to develop a video-based instructional module in DVD



format, which incorporated certain design elements based upon cognitive theories of multimedia learning, to instruct high school automotive students, and have students from the College of Education at the University of Hawai'i at Mānoa evaluate the module's structure, interface, functionality, and delivery of content. The results of this study suggest that incorporating specific design elements increases content retention. Providing participants the opportunity to modify the instructional module's pace and sequence to accommodate their individual cognitive needs and skills appears to have resulted in a positive effect on learner outcome, as indicated by both the test results and the participants' Likert Scale responses.

Individual design elements were not examined in isolation; therefore the impact of each design element couldn't be objectively ascertained, although in their totality, they appeared effective. Many of the responses to the open ended questions were too brief to be as illuminating as they might have been. If interviews had followed the study, they might have resulted in a more in-depth understanding.

The next step with this module would be testing to verify if secondary education students would have similar responses to the same module. The results would indicate what modifications might be needed.

### **Future Research**

Studies need to be conducted to determine if multimedia-based instruction can be taken to the next level for secondary education automotive technology students, determining the proper tool(s) to use in a given situation. This study indicated that multi-media, which incorporates certain design elements, results in increased retention, but would it also result in increased ability to transfer this knowledge to application upon the shop floor?

Research related to multimedia and hands-on courses for secondary education students is an area ripe for exploration. The zeitgeist supports it; digital natives seek out YouTube for quick tutorials, thus they naturally gravitate toward video as a means to acquire knowledge and skills. Procedural tasks, such as those that form the basis for elementary automotive technology classes, seem to be ones which could be taught effectively using video instructional modules, due to the viewer's ability to customize the instruction in terms of pacing and sequence. While Schwan and Rienpp (2004) found that procedural tasks can be taught effectively using video, would further research validate their findings, particularly at the secondary level? The role of color also merits further research. The results of one study, pertaining to slides, strongly implied that screen color's impact upon learner performance depends on the type of cognitive task required at the time Clariana (2004). Does color also affect video based instructional modules, if so, how?

The continuing challenge lies in designing the most effective video-based instructional modules. There is a reciprocal relationship between learning theorists and educational practitioners (Mayer 2002). Practical educational problems often provide the catalyst for the research of cognitive theorists, and the best teaching practices are based upon sound cognitive theories, which are always evolving.

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